LETTERS

The coming acceleration of global population ageing

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The future paths of population ageing result from specific combinations of declining fertility and increasing life expectancies in different parts of the world[1]. Here we measure the speed of population ageing by using conventional measures and new ones that take changes in longevity into account for the world as a whole and for 13 major regions. We report on future levels of indicators of ageing and the speed at which they change. We show how these depend on whether changes in life expectancy are taken into account. We also show that the speed of ageing is likely to increase over the coming decades and to decelerate in most regions by mid-century. All our measures indicate a continuous ageing of the world's population throughout the century. The median age of the world's population increases from 26.6 years in 2000 to 37.3 years in 2050 and then to 45.6 years in 2100, when it is not adjusted for longevity increase. When increases in life expectancy are taken into account[2,3], the adjusted median age rises from 26.6 in 2000 to 31.1 in 2050 and only to 32.9 in 2100, slightly less than what it was in the China region in 2005. There are large differences in the regional patterns of ageing. In North America, the median age adjusted for life expectancy change falls throughout almost the entire century, whereas the conventional median age increases significantly. Our assessment of trends in ageing is based on new probabilistic population forecasts. The probability that growth in the world's population will end during this century is 88%, somewhat higher than previously assessed[4]. After mid-century, lower rates of population growth are likely to coincide with slower rates of ageing.

Conventional measures of ageing are based on chronological age. They assume that a 60-year-old person in 1900 was just as old as a 60-year-old person in 2000 because each has lived the same number of years. However, would we say that the two have aged at the same rate? After all, the 60-year-old in 2000 would, on average, have many more remaining years of life. Population ageing is not only about there being more old people (by today's definition of what is old): it is also about people living longer lives[5]. To capture this important impact of increasing life expectancy on our lives, and on the definitions of what is age and what is old, we introduce and quantify three new indicators of age that explicitly take changes in the remaining life expectancy into account. Although traditional age still greatly matters for institutional arrangements such as pension systems in most countries, the alternative measures tell us more about the changing human condition in which more people can plan for a longer and healthier life with consequences for their behaviour.

The conventional measures considered here are the proportion of the population aged 60+ (Prop. 60+), the median age of the population (MA) and its average age (Aver. Age). The alternative approach to measuring the proportion of elderly people in the population does not depend on a fixed age boundary but, rather, on a fixed remaining life expectancy. We define Prop. RLE 15− as the proportion of the population in age groups that have a remaining life expectancy of 15 years or less (see ref. 6 for the suggestion of a similar measure). If longevity increases, the minimum age of people included in Prop. RLE 15− increases. The adjusted version of the median age is called standardized or prospective median age (PMA)[2,3]. It is the age of a person in the year 2000 who has the same remaining life expectancy as a person at the median age in the year under consideration. The change in the prospective median age over some time period is roughly the change in the median age minus the change in life expectancy at the median age.

The adjusted version of the average age is the population average remaining years of life (PARYL). It is the weighted average of age-specific remaining life expectancies, where the weights are the proportions of the population at each age[7,8]. PARYL gives us the average remaining years of life of population members. Unlike the other measures, PARYL goes down as a population ages. We intuitively think of populations being younger when, on average, its members have more years left to live and PARYL is higher.

Figure 1 shows four of these measures of ageing as they evolve over time for the global population. All six measures are listed in Table 1 for selected regions and dates (information for all regions is given in Supplementary Table 2). All of them indicate that ageing will continue throughout the century. The two most rapidly increasing indicators, the proportion of the population 60+ years old and the median age of the population, are based on the traditional definition of age, hence suggesting the need for institutional adjustments to cope with these expected increases. The proportion of the global population 60+ years old increases from 10.0% in 2000 to 21.8% in 2050 and then to 32.2% in 2100. The three measures that are adjusted for longevity change show a slower pace of change.

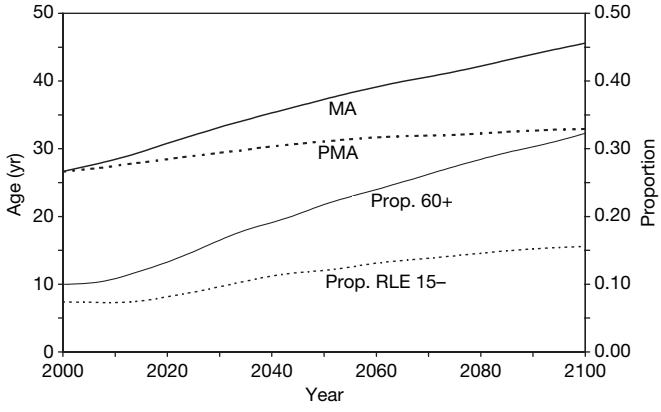

Figure 1 | Projected changes in the level of ageing for the world population over the course of the century for four indicators of ageing as defined in the text.

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Table 1 | Indicators of ageing

Region	Indicator	2000	2005	2010	2020	2030	2040	2050	2075	2100
North America	Aver. Age	36.5	37.0	37.7	39.5	41.3	42.6	43.6	46.5	49.5
	Prop. 60+	0.16	0.17	0.18	0.23	0.27	0.28	0.30	0.35	0.39
	PARYL	43.0	43.3	43.4	43.5	43.6	44.1	45.0	46.3	48.4
	MA	35.9	36.7	37.2	38.4	40.3	41.9	43.0	47.0	50.0
	Prop. RLE 15−	0.11	0.10	0.10	0.11	0.13	0.15	0.14	0.15	0.15
	PMA	35.9	35.8	35.4	34.7	34.8	34.6	33.7	33.0	30.9
Middle East	Aver. Age	24.2	25.1	26.0	28.3	31.4	34.4	37.1	42.6	46.6
	Prop. 60+	0.06	0.06	0.06	0.08	0.10	0.14	0.19	0.28	0.34
	PARYL	48.8	48.8	48.7	48.3	47.0	45.8	44.9	43.5	43.7
	MA	19.9	21.2	22.6	25.5	28.7	32.3	35.9	42.4	47.4
	Prop. RLE 15−	0.04	0.04	0.04	0.05	0.06	0.07	0.09	0.13	0.16
	PMA	19.9	20.3	20.9	22.0	23.5	25.5	27.6	30.0	30.6
South Asia	Aver. Age	26.5	27.1	27.8	29.8	32.2	34.6	37.0	42.4	47.3
	Prop. 60+	0.07	0.07	0.08	0.09	0.12	0.14	0.17	0.26	0.35
	PARYL	44.1	44.1	43.9	43.2	42.1	41.2	40.4	38.6	37.6
	MA	22.7	23.4	24.5	26.9	29.6	32.8	35.9	42.6	48.5
	Prop. RLE 15−	0.06	0.06	0.06	0.07	0.08	0.10	0.11	0.16	0.19
	PMA	22.7	22.9	23.4	24.7	26.3	28.3	30.2	33.7	36.2
China region	Aver. Age	31.2	33.2	35.1	38.6	42.3	45.5	47.7	50.7	51.2
	Prop. 60+	0.10	0.11	0.12	0.17	0.24	0.30	0.35	0.41	0.42
	PARYL	43.4	42.1	41.0	39.0	36.9	35.5	35.0	36.1	39.3
	MA	29.6	32.3	34.7	38.5	43.0	47.5	50.7	53.7	54.0
	Prop. RLE 15−	0.07	0.08	0.08	0.11	0.14	0.19	0.21	0.24	0.22
	PMA	29.6	31.7	33.5	36.0	39.3	42.3	44.1	43.0	38.6
Pacific Asia	Aver. Age	28.2	29.3	30.5	33.0	35.4	37.6	39.5	43.2	47.5
	Prop. 60+	0.08	0.08	0.09	0.12	0.16	0.20	0.23	0.29	0.36
	PARYL	44.7	44.4	43.9	42.9	42.1	41.5	41.2	41.2	41.1
	MA	25.3	26.9	28.4	31.4	34.0	36.4	38.6	43.3	48.7
	Prop. RLE 15−	0.06	0.06	0.07	0.08	0.10	0.12	0.14	0.15	0.17
	PMA	25.3	26.2	27.1	28.7	29.9	30.9	31.6	32.4	33.7
Japan/Oceania	Aver. Age	40.4	41.6	43.0	45.7	47.9	49.7	51.3	54.1	57.7
	Prop. 60+	0.22	0.24	0.27	0.31	0.35	0.40	0.42	0.47	0.51
	PARYL	41.3	41.0	40.6	39.7	39.5	39.5	39.6	41.1	43.0
	MA	40.0	41.3	42.8	46.7	49.9	52.1	53.9	57.6	61.1
	Prop. RLE 15−	0.13	0.13	0.14	0.17	0.18	0.18	0.20	0.21	0.21
	PMA	40.0	40.3	40.9	42.9	44.3	44.6	44.5	43.3	41.7
Western Europe	Aver. Age	38.3	39.1	40.1	42.4	44.7	46.8	48.4	51.0	53.5
	Prop. 60+	0.20	0.20	0.21	0.25	0.31	0.34	0.37	0.42	0.46
	PARYL	41.0	41.0	40.8	40.3	39.8	39.6	39.7	41.4	43.5
	MA	36.8	38.3	40.0	43.1	45.8	48.2	50.2	53.5	56.5
	Prop. RLE 15−	0.13	0.13	0.13	0.14	0.15	0.18	0.19	0.20	0.19
	PMA	36.8	37.5	38.3	39.6	40.5	41.1	41.3	39.8	37.7
Eastern Europe	Aver. Age	37.0	38.4	39.8	42.7	45.6	48.2	50.3	52.4	52.4
	Prop. 60+	0.18	0.18	0.20	0.25	0.29	0.36	0.42	0.44	0.44
	PARYL	39.7	39.1	38.5	37.3	36.0	35.3	34.9	36.9	40.6
	MA	35.6	37.1	38.9	42.9	47.3	51.3	54.0	55.7	55.7
	Prop. RLE 15−	0.13	0.13	0.13	0.15	0.18	0.19	0.22	0.24	0.21
	PMA	35.6	36.4	37.4	39.9	42.8	45.2	46.3	43.5	38.6
World	Aver. Age	29.7	30.4	31.3	33.1	35.2	37.1	38.8	42.3	45.5
	Prop. 60+	0.10	0.10	0.11	0.13	0.17	0.19	0.22	0.27	0.32
	PARYL	43.8	43.6	43.3	42.8	42.1	41.6	41.3	41.0	41.2
	MA	26.6	27.5	28.4	30.8	33.2	35.3	37.3	41.4	45.6
	Prop. RLE 15−	0.07	0.07	0.07	0.08	0.10	0.11	0.12	0.14	0.16
	PMA	26.6	27.0	27.5	28.5	29.4	30.4	31.1	32.1	32.9

Prop. RLE 15− goes from 7.4% in 2000 to 12.0% in 2050, and then to 15.6% in 2100. As to regional differentials, Table 1 shows that Japan/Oceania is the oldest region today and is likely to keep this position throughout the century with its median age likely to increase to above 60 years. It is closely followed by the European regions. North America shows much slower ageing and is likely to be surpassed by China for every indicator of ageing by 2030–40.

Figure 2 shows the accelerating and then decelerating speed of ageing at the global level. It plots decadal changes in the level of the indicator divided by the maximum increase (speed) projected over the century. For all indicators, the speed accelerates over the coming years reaching the highest rate of increase before 2035. After that, the speed of ageing is expected to decelerate although there will be further increases in the level of ageing throughout the century. This analysis clearly shows that, even under widely differing definitions of ageing, the world is expected to experience a significant acceleration in the speed of population ageing over the coming years.

How certain are these projected future trends in ageing? Is the expected rapid increase in ageing in many parts of the world a near

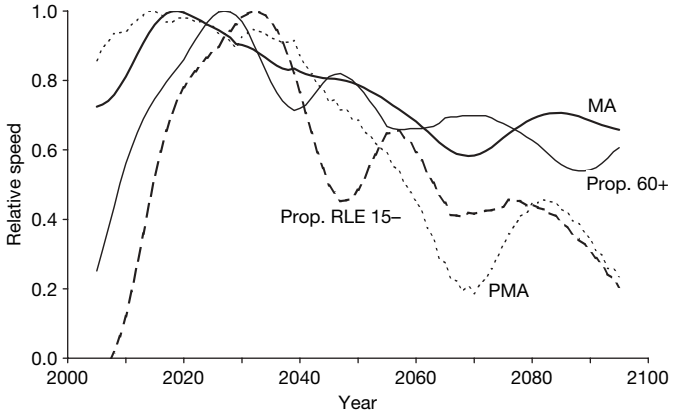

Figure 2 | The changing speed of increase in selected indicators of ageing. This is calculated as increases per decade in the level of the indicator divided by the maximum increase projected over the century; on the time axis, values are allocated to the middle of the decade considered.

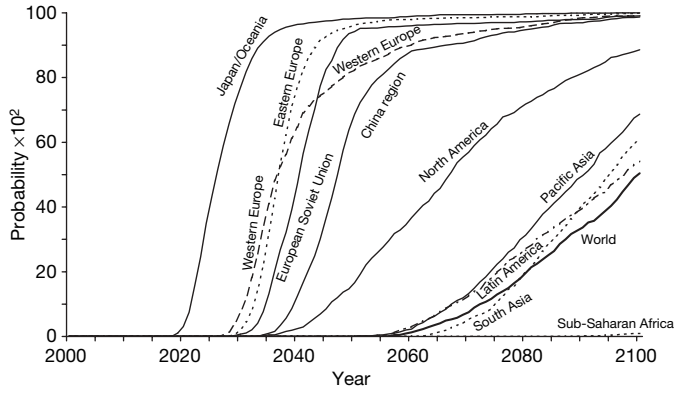

Figure 3 | Cumulative probabilities of reaching a proportion 60+ of one-third or more for the world and selected world regions by calendar year.

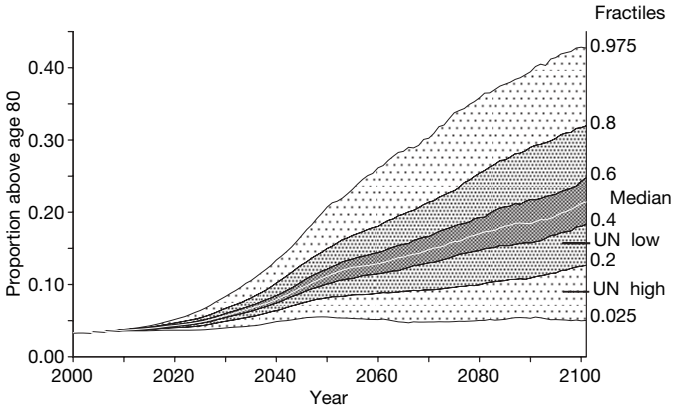

Figure 4 | Fractiles of the projected uncertainty distribution of the proportion of the population above age 80 in Western Europe. Straight lines in 2100 indicate the values given by the high and low variants of the United Nations (UN) long-term population projections.

certainty or just one out of several possible scenarios? The probabilistic nature of our population projections explicitly addresses this issue. Figure 3 shows the cumulative probabilities that different world regions reach one-third of their population 60+ years old (Prop. 60+) over the course of the century. By mid-century, the chance of having passed this specific ageing threshold is 98% in Japan/Oceania, 82% in Western Europe and even 69% in the China region. Uncertainty is so low in these regions because past fertility and mortality declines have already altered the age structures significantly. North America has a 50% chance of crossing this threshold in the 2060s owing to its currently still younger age structure and anticipated future migration gains. For sub-Saharan Africa, which still has an extremely young population with 44% of the population below age 15, the chance of Prop. 60+ being more than a third of the population is close to zero, even by the end of the century. For all other regions the chances start to increase over the 2060s and 2070s and reach around 50% by the end of the century. For the world as a whole, the cumulative probability turns out to be exactly 50% in 2100.

Figure 4 demonstrates another advantage of studying ageing from a probabilistic viewpoint. It shows predicted distributions of the proportion above age 80 for Western Europe (see Supplementary Table 1 for data on all regions). The proportion 80+ is almost certain to increase significantly over the coming decades. The projected increase in this indicator is very sensitive to the assumptions about future trends in old-age mortality where our assumed uncertainty ranges reflect tremendous disagreement among scientists[9–16]. Figure 4 shows that the 95% prediction interval is 5.5–20.7% by 2050 and 5.0–42.8% by 2100. The small lines inserted in 2100 give the results from the high and low variants of the most recent United Nations long-range projections[17]. These only reflect alternative fertility levels because the United Nations does not publish variants considering mortality uncertainty. That approach leads to a gross underestimation of the uncertainty of the future proportions of elderly.

Population ageing has many dimensions that will affect individuals and societies alike. When we supplement the conventional measures of ageing with ones that incorporate longevity change, we obtain a more complete understanding of how these dimensions are expected to evolve. In addition to changes in its level, the speed of ageing matters because, generally, the difficulties of adaptation to demographic change increase with the speed of change. In this respect, the world as a whole and the low fertility countries in particular face the challenge of an accelerating speed of ageing over the coming decades with the prospect of a slower speed of ageing at a higher level towards the second half of the century.

METHODS SUMMARY

The population forecasts presented here are an update of earlier probabilistic forecasts published in 2001[4]. A fuller list of the results of this update is given in Supplementary Table 1. Although the methodology and the longer-term assumptions have not changed, the new forecasts reflect empirical trends and new data available up to 2006. One methodological innovation lies in the consideration of uncertainty ranges for starting conditions in certain regions of the world with unreliable information. This was particularly relevant for the assumed level of current fertility in China, where published total fertility rates range from 1.2 to 1.8. After a review of 18 different estimates[18], we assumed a median total fertility rate of 1.5 and an 80% uncertainty range from 1.3 to 1.7 as starting conditions. This change causes a downward shift in the projected long-term global population size, which is offset by the effects of the observed slower decline of fertility in sub-Saharan Africa, leaving forecasted world population sizes largely unaffected. Sensitivity analyses showed that the main findings about the coming acceleration of global ageing hold, even if China is excluded from the simulations. The proportion of our simulations that show a peak in the world's population some time during the century increases from 86% in our previous forecasts to 88% in our current ones (see Supplementary Figure 1). The forecasting methodology is described in ref. 4 and all the long-term assumptions are described and justified in detail in ref. 19. New short- and medium-term fertility assumptions are given in Supplementary Table 3. The mortality and migration assumptions were unchanged. The list of countries in each region appears in ref. 19.

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